REMARKS

This amendment consists of argumentation based on the subject matter disclosed in the cited prior art references. No claim changes have been made. The pending claims remain the claims in the amendment filed on July 26, 2011.

I. The Applicants' Claimed Methods

The applicants' claimed methods according to independent method claims 8, 17, 22, and 23 are limited to:

a) treatment of refractory material that has a composition containing alumina, silica, zirconia and another oxide ingredient, which is magnesia or chromia;

b) treatment of refractory bricks, which are known to have pre-selected composition limitations that are *not* present in ordinary bricks used in building construction (as in Li) in order to withstand the high temperatures and rapid temperature changes, e.g. due to contact with a glass melt;

c) treatment of the surface of the refractory material with laser radiation from only one laser, which is limited to a CO_2 laser, *preferably* which introduces from 2 to 4

W per mm^2 into the surface of the refractory material (*claim 3*);

d) the treatment with the laser produces a closed (non-porous) surface layer;

e) the closed surface layer produced by the laser treatment is vitreous or glassy, i.e. non-crystalline;

f) in the case of claims 22 and 23 (methods of manufacturing glass products) the method includes bringing a glass melt in contact with the closed vitreous surface layer.

II. First Obviousness Rejection

Claims 22, 23, 26 and 27 were rejected as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, and further in view of Li, WO 95/35269.

Recasens does disclose refractory bricks comprising comparatively large amounts of alkali or alkaline earth oxides, as well as alumina, silica, zirconia and chromia. The comparatively large amount of alkali or alkaline earth oxides produces a low melting sodium silicate phase, which acts as a vitreous phase to

hold together crystalline phase regions. The comparatively large content of low melting silicate makes it easier to cast the refractory material and reduces the attack of chromium in the brick by the surrounding atmosphere.

However Recasens does **not** disclose or suggest any laser treatments of the surface of the refractory bricks that are performed in order to improve the resistance of the refractory material surface to corrosion or erosion due to contact with a glass melt. Recasens does **not** motivate one skilled in the art to modify any of the methods of strengthening refractory material or refractory bricks that include laser treatment of the surface of the brick, such as those of Wang and Li, because Recasens teaches an entirely different solution to the problem of strengthening the resistance of refractory material to a glass melt. Recasens teaches selection of a special refractory material composition with amounts of the various oxides in certain ranges according to column 1, lines 45 to 53, which provide a refractory brick made with that composition with superior resistance to corrosion due to contact with a glass melt than those of the prior art (see column 1, lines 29 to 41). Recasens finds that compositions with comparatively large amounts of chromia over 50 wt. % and comparatively small amounts of zirconia below 50 wt. % provide the best resistance to corrosion by a glass melt (see the

Table in columns 5 and 6).

Thus Recasens leads one skilled in the art away from treating the refractory brick surface with laser radiation to strengthen the resistance to corrosion by a glass melt, because Recasens suggests an alternative solution: adjusting the resistance to corrosion by a glass melt by varying the composition of the oxide components, especially zirconia and chromia, of the refractory material. A prior art reference that leads one skilled in the art away from the claimed invention should not be combined with other prior art references to reject the claimed invention under 35 U.S.C. § 103 (a) as explained in e.g. M.P.E.P. § 2145 X and various U.S. Court decisions.

The obviousness rejection need not rely on Recasens, because as pointed out on page 3 of the Office Action Wang on page 294 does disclose refractory bricks used in their laser treatment, which contain alumina, silica and zirconia. These bricks also include a small amount of MgO instead of Chromia, but their particular composition falls within the composition according to applicants' claims 22 and 23.

Furthermore Recasens does not seem to teach anything that would suggest modifications of the laser treatments of Wang and/or

Li and/or the refractory material composition described in e.g. Wang, which would help one skilled in the art arrive at the applicants' methods as claimed in claims 22 and 23.

In addition, one skilled in the art knows that refractory bricks with the compositions according to Recasens can generally only be used for melting low-melting glass batches, for example soda lime glass, because their resistance to the higher melting glass batches is not sufficient.

Wang teaches a method of strengthening a refractory material of a composition similar to that according to applicants' claims 22 and 23 to reduce or prevent surface erosion by exposing the surface to a high power CO_2 laser beam to produce a sealed or closed surface layer without cracks or pores (see abstract).

However the laser treatment of Wang produces a surface layer that is crystalline, not glassy or vitreous as required by applicants' claims 22 and 23. This is apparent from the microstructures shown in the micrographs of the surface layer produced by the electron (see section 2 on pages 294-295 and figs. 4 to 6). According to section 3.2 on page 296 these micrographs show that the surface layer has an oriented dendrite structure. Section 3.3 on page 297 of

the article teaches that the X-ray diffraction patterns of fig. 6 before and after laser treatment show that a dominant mullite phase ($Al_6Si_2O_{13}$) of the refractory material, which is present in the untreated material, is converted by the CO_2 laser treatment to α-Al_2O_3 (corundum) and a small amount of c-ZrO_2. However mullite is a crystalline phase; it is **not** a glassy or vitreous phase. Webster's dictionary available on the internet teaches that Corundum is a crystalline material; mullite is also crystalline. Thus the surface layer produced by the laser treatment of Wang is crystalline, not glassy or vitreous as required by applicants' claims 22 and 23.

Wang does not characterize their surface layer as vitreous or amorphous and only teaches that the layer is composed of specific crystalline phases. A reference is only good for what it teaches; there is no location in Wang cited in the latest Office Action, which teaches that the surface layer is vitreous. If that is the contention, then evidence should be provided in the form of another reference or the like in which the same treatment conditions and parameters are employed with a refractory material with the same or similar composition, which states that the surface treated layer is glassy or vitreous.

The change from a dominant mullite phase to a corundum phase is primarily due to the high intensity of the laser beam, which is about 10 times more intense than applicants. The higher laser power causes the evaporation of silica from the surface layer and hence the transition to an alumina surface layer (see page 301, points 3 and 4, in the "Conclusions" section).

One skilled in the art would understand that a layer that is characterized as "closed and vitreous" according to applicants' method claims 22 and 23 would not have a dominant crystal phase, such as a dominant corundum phase. Having a dominant crystal phase means that the major portion of the layer is crystalline. Furthermore the micrographs confirm that the dendrite structure uniformly and completely covers the entire surface region of the refractory material from the surface to about 1000 μm below the surface.

Thus Wang could not be combined with Recasens to arrive at the methods claimed in claims 22 and 23, because the result of performing the laser treatment of Wang (crystalline surface layer) is different from the applicants' result (vitreous or glassy surface layer).

WO 95/35269, Li, et al, discloses a method of treating the surface of a conventional brick used in construction of brick buildings (**not** refractory bricks) with CO_2 laser beam (page 3, last paragraph) to achieve directly melting of a surface layer to form a "glazing" (see the abstract of Li, et al). According to p.3, second paragraph, last line, of Li, et al, the glazing comprises an amorphous, i.e. vitreous layer (glassy).

Bricks used in building construction generally have a composition comprising 50 to 60 % by weight silica, 20 to 30 % alumina, 2 to 5 % lime (CaO), 5 to 6 % iron oxide and about one percent of magnesia according to the Wikipedia encyclopedia available from the Internet. That is in general agreement with the disclosures of the brick compositions on page 1 of the specification of Li. However page 3, lines 12 to 14, of Li, et al, teaches that in order to produce a vitreous layer with a laser treatment, the brick should have a "high SiO_2 content", presumably meaning > 50 %. In contrast, the bricks of Recasens, et al, and also firebrick in general have comparatively low silica content from about 7 to 16 wt. % of silica. Also the major component in the bricks of Wang (p. 294 in Applied Surface Science Vol. 221) is alumina, not silica, at about 75 % according to section 2 on page 294 of Wang. The amount of silica in the bricks of Wang is less than 9.5 wt. % compared with more

than 50 wt. % in the conventional non-refractory bricks of Li.

Thus Li teaches against the formation of a surface layer that is glassy or vitreous on the bricks with the composition according to Wang on page 3 of WO '269 by their laser glazing methods, because Li teaches that the bricks should have high silica content (> 50 %) in order to form a glassy or vitreous surface layer when the glazing method is performed, but the silica content in the bricks of Wang is less than 10 wt. %. A prior art reference, such as Li, that teaches that the bricks must have a composition that is the opposite from those of Wang, in order to form a glassy or vitreous layer using a CO_2 laser treatment, can hardly be combined with Wang to suggest that the treatment of Wang can be modified to produce a glassy or vitreous layer on the refractory material of Wang, especially when Wang has only been able to obtain a surface layer which is largely crystalline.

Whether or not a given laser beam of a given frequency and intensity (power) produces a given effect, such as the formation of a vitreous or glassy layer, on a glass or ceramic material would necessarily depend greatly on the composition of the material, including e.g. whether or not the material comprises oxides that are easily melted or not. Although obviousness does not require

absolute predictability, at least some degree of predictability is required. See M.P.E.P. § 2143.03 and ***In re Rinehart***, 189 U.S.P.Q. 143 (C.C.P.A. 1976). Also see the more recent tests in M.P.E.P. § 2143 derived from the *KSR* decision, which all require a reasonable expectation of success for the proposed combination of prior art features. The chemical arts, in contrast to the mechanical arts, are generally somewhat unpredictable despite the advances of recent years. Here in the case of the instant claims there is no reason for one of ordinary skill in the art to expect that, if the chemical compositions of the bricks of two different prior art references are substantially different from each other, the success of obtaining a particular effect by laser treatment in the method disclosed in one of the prior art references does not lead to a conclusion that the same effect could be produced by the laser treatment in the method disclosed in the other reference.

In fact, the teaching of Li suggests the opposite, namely that one could **not** form a vitreous or glassy layer with the methods disclosed in Wang because the proportion of silica in the brick of Wang is much too low; Li teaches a high proportion is required. Also the fact that applicants' claims do not include specific amount ranges for silica and alumina and other components is not relevant; only the teachings of Wang and Li regarding brick composition are

relevant for the aforesaid argumentation, because the issue is what is actually suggested by the combination of these two references to one skilled in the art.

In addition, the glazed bricks of Li are known to be totally unsuitable for glass manufacturing processes; otherwise they would have been used to make e.g. a melting furnace. If a glazing method does not put conventional bricks in a position in which they can be used in glass manufacturing, then one skilled in the art would not find it obvious to use glazing techniques to improve high performance fusion-cast refractory bricks.

Applicants appreciate that the CO_2 laser operates to produce a laser beam with lower power densities of from 2 to 2.5 W/mm^2 (p. 4 of Li), as noted on page 4 of the Office Action. However applicants do not merely claim in their dependent claim 3 that the laser beam has this sort of power density, but instead teach and claim that a power density of 2 to 4 W/mm^2 is "introduced into the surface" (claim 3), which means absorbed by the refractory material. Merely because a material is exposed to a laser beam of a certain power does not mean that the entire beam energy is absorbed; indeed often most of the energy is transmitted or reflected.

Thus the laser operating parameters for the laser of Li are not necessarily the same as those of the applicants (and also those of Wang) and thus would not necessarily lead to the same results, even if the a refractory material of the same composition was treated by the method of Li and methods of the applicants.

For the aforesaid reasons withdrawal of the rejection of claims 22, 23, 26 and 27 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, 2004, pp. 293 to 301, and further in view of Li, WO 95/35269, is respectfully requested.

III. Second Obviousness Rejection

Claims (2-6)/17, 17-19, 21 and 25 were rejected as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, *2004*, pp. 293 to 301, and further in view of Li, WO 95/35269, further in view of Torok, et al, US 3,360,353, as evidenced by Triantafyllidis, et al, Applied Surface Science, Volume **186,** *2002*, pp. 140 -144.

Independent claim 17 claims a method with all the limitations listed in section I above, namely a method of treating a refractory

material of the composition according to section I with a laser beam from a single CO_2 laser to form a closed and vitreous layer on the surface of the refractory material. Recasens and Wang have been described above. According to the argumentation in section II above the combination of Recasens and Wang does not lead to method that produces a refractory material with a closed and vitreous or glassy layer as claimed in independent claim 17.

Claim 17 was further limited to treating a Danner blowpipe or a drawing die that is made with the refractory material as described in section I above to provide a glassy or vitreous closed surface layer. Torok does disclose a Danner blowpipe or a drawing die that is made with refractory material, but the composition of the refractory material is unspecified in Torok. As noted above, the composition is critical regarding the predictability of methods of treating the surface of the refractory material to provide increased resistance to erosion caused by a glass melt.

More significantly, Torok, et al, do not teach anything regarding <u>laser</u> treatments of the surface of refractory materials and especially treatments that produce a vitreous or glassy surface layer that makes them more resistant to corrosion or erosion due to contact with a glass melt. Torok, et al, cannot cure any of the

deficiencies of the combined subject matter of Recasens, et al, and especially Wang, et al, which were pointed out in section II above and which must be cured to arrive at the treatment method according to claim 17 (which is the same as the treatment method recited in claims 22 and 23).

Page 7 of the Office Action refers to the "laser-treated" refractory bricks of Recasens. Recasens does not treat any bricks with a laser.

Triantafyllidis, et al, was only cited on page 7 for its disclosure of the wavelength of the CO_2 laser recited in dependent claim 6 in order to support the rejection of claim 6/17.

Regarding any other application of subject matter from Triantafyllidis, et al, this reference describes laser treatment of an alumina based ceramic named Resistal KR85C used as a heat insulation material in waste incineration plants. Resistal KR85C is highly porous, namely 14.1 ± 0.9 %. The laser treatment of the surface does produce a denser surface layer but the reference clearly shows that the layer is predominantly composed of crystalline phases (see fig. 2 on page 142).

Furthermore as noted in previous amendments Triantafyllidis, et al, uses a two-beam process to make the surface even denser and to temper the surface treated with the high power CO_2 laser in order to avoid crack formation due to the high power densities. The applicants' claims were amended to include further limitations to limit their claims to treatment with a single laser beam from a CO_2 laser.

Accordingly Triantafyllidis, et al, cannot be combined under 35 U.S.C. § 103 (a) with Recasens, Wang and Li in order to arrive at the method as claimed in claim 17.

For the aforesaid reasons withdrawal of the rejection of claims (2-6)/17, 17-19, 21 and 25 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, *2004*, pp. 293 to 301, and further in view of Li, WO 95/35269, further in view of Torok, et al, US 3,360,353, as evidenced by Triantafyllidis, et al, Applied Surface Science, Volume **186,** *2002*, pp. 140 -144 is respectfully requested.

IV. Third Obviousness Rejection

Claims 8, (2-6)/8, 17-19, 21 and 25 were rejected as obvious

under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, *2004*, pp. 293 to 301, and further in view of Li, WO 95/35269, further in view of Torok, et al, US 3,360,353, and further in view of Petitbon, US 4,814,575.

Independent claim 8 claims a method with all the limitations listed in section I above, namely a method of treating a refractory material of the composition according to section I with a laser beam from a single CO_2 laser to form a closed and vitreous layer on the surface of the refractory material. Recasens and Wang have been described above. According to the argumentation in section II above the combination of Recasens and Wang does not lead to a method that produces a refractory material with a closed and vitreous or glassy layer as claimed in independent claim 17.

Petitbon does disclose treating the surface of a ceramic material with laser radiation from a CO_2 laser and simultaneously spraying ceramic powder on the surface to further reduce the porosity of the laser treated surface (column 2, lines 41 and following; claim 1).

The method of Petitbon does involve treating the surface of the ceramic material with the high power beam from a continuous

CO_2 laser, which has a rated power of 3 kW and a beam diameter of 4 mm, which is thus similar to the high power laser of Wang, et al, which is distinguished from that of the applicants. The operating parameters for the preferred ceramic materials mentioned in the above paragraph are (column 4, lines 35 to 42):

Laser power density 6 to 12 kW/cm^2,

Laser energy density of 0.2 to 1 kJ/cm^2,

Scanning speed 1 to 20 cm/s, and

alumina or zirconia powder throughput 1 to 5 grams/min.

The laser operating parameters overlap those of Wang, et al, but the laser power densities of Petitbon, like those of Wang, et al, are more than an order of magnitude greater than applicants. Claim 3 of applicants claims preferred power densities of 2 to 4 W per mm^2 in comparison to 60 to 120 W/mm^2 for Petitbon.

Thus one skilled in the art would expect the same result in Petitbon as in Wang: a surface treated layer that is substantially crystalline, which is not a glassy or vitreous layer. The rebuttal argument in paragraph 21 on page 13 of the Office Action relies on the disclosures in Li, et al. However Li teaches that the composition of the brick that they treat in their laser glazing methods is important to obtain a glassy or vitreous layer and is the opposite

from those of Wang. Thus one would not expect a glassy or vitreous layer from the treatment of Petitbon.

Regarding the rebuttal argument in paragraph 20 on page 13 of the Office Action is the Examiner suggesting that the composition of a material is unimportant for the results of a laser treatment of the material? The composition and structure of a material determine the absorption spectra of the material, which determines the fraction of the radiant energy that is absorbed from a light beam. In fact, Li teaches that the composition of the bricks treated by their laser glazing methods is critical to obtain their desired results (page 3, lines 12 to 14, of Li, et al). The Office Action does not refute the contention in the previous arguments that the materials that Petitbon treats are entirely different from those according to claim 8.

The *KSR* Supreme Court Opinion (*KSR Int'l Teleflex Inc.*, 82 USPQ 2^{nd} 1385, 1396 (2007)) suggests several tests for obviousness (M.P.E.P. 2143) including an obvious-to-try test which provides a valid reason to reject a claimed invention for obviousness, **provided that** a limited number of possibilities that have predictable results are available and known to one of ordinary skill in the art. Several of the other tests, such as the test for combining known elements, also require that the outcome of the

combination should be predictable (M.P.E.P. § 2143).

Laser treatment of materials requires setting and adjusting a number of different experimental parameters and controlling certain experimental variables as the applicants' dependent claims 2 to 6 illustrate. It is not particularly easy to identify the parameters that must be optimized to achieve a specific result, such as a vitreous as opposed to a crystalline surface layer, because of the comparatively large number of parameters. Furthermore the prior art references do not identify a result-effective variable that can be optimized to eliminate the crystalline regions from the surface layer that result from laser treatment (M.P.E.P. § 2144.05 II A. B.). In fact, Li suggests optimizing an amount of silica rather than the laser power absorbed by the refractory material. Thus one skilled in the art would not find the applicants' inventive method obvious from the combined prior art references.

Although obviousness does not require absolute predictability, at least some degree of predictability is required. See M.P.E.P. § 2143.03 and ***In re Rinehart***, 189 U.S.P.Q. 143 (C.C.P.A. 1976). The chemical arts, in contrast to the mechanical arts, are generally somewhat unpredictable despite the advances of recent years.

In the case of the instant claims it is **not** predictable that the methods of Wang, et al, and Li, et al, and Petitbon could be successfully applied to refractory material of the claimed composition in claim 8 or indeed the refractory material as disclosed in Recasens, which comprises substantial amounts of silica and chromia or magnesia, in order to produce a glassy or vitreous layer on the surface that comprises substantial amounts of silica. In fact the teaching of Wang, et al, and Li, et al, together with Petitbon suggests the opposite, because Li, et al, teaches that the composition of the bricks should have more than 50 wt. % of silica in order to form a glassy or vitreous layer.

Furthermore a refractory surface layer that is vitreous has greater mechanical strength than a largely crystalline layer and is thus advantageous for glass processing (p. 2, lines 20 to 24, of applicants' specification).

For the aforesaid reasons withdrawal of the rejection of claims (2-6)/17, 17-19, 21 and 25 as obvious under 35 U.S.C. § 103 (a) over Recasens, et al, in view of Wang, et al, Applied Surface Science, Volume **221**, *2004*, pp. 293 to 301, and further in view of Li, WO 95/35269, further in view of Torok, et al, US 3,360,353, and further in view of Petitbon, US 4,814,575, is respectfully requested.

Should the Examiner require or consider it advisable that the specification, claims and/or drawing be further amended or corrected in formal respects to put this case in condition for final allowance, then it is requested that such amendments or corrections be carried out by Examiner's Amendment and the case passed to issue. Alternatively, should the Examiner feel that a personal discussion might be helpful in advancing the case to allowance the Examiner is invited to telephone the undersigned at 1-631-549-4700.

In view of the foregoing, favorable allowance is respectfully solicited.

Respectfully submitted,

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